MODIFICATIONS IN AMBIENT AIR-COOLED VAN CONTAINER FOR TRANSPORTING AGRICULTURAL PRODUCTS TO OVERSEAS MARKETS

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PREFACE

This project is part of the broad program of the Agricultural Marketing Research Institute of the Agricultural Research Service, U.S. Department of Agriculture, to improve the distribution of agricultural products for the benefit of farmers, consumers, and private industry.

The research was conducted in cooperation with private companies including ocean carriers, shippers, marketing cooperatives, and container leasing firms.

Special credit is due the following individuals of the Agricultural Research Service: Philip W. Hale and Thomas Moffitt of the U.S. Horticultural Research Laboratory, Orlando, Fla., B. Hunt Ashby and William A. Bailey of the Transportation and Packaging Research Laboratory, Beltsville, Md., and Anton Bongers of the European Marketing Research Center, Rotterdam, The Netherlands. This research was done under the leadership and guidance of P. L. Breakiron, Chief, Transportation and Packaging Research Laboratory, Beltsville, Md.

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MODIFICATIONS IN AMBIENT AIR-COOLED VAN CONTAINER FOR TRANSPORTING AGRICULTURAL PRODUCTS TO OVERSEAS MARKETS

By W. G. Kindya 1/

INTRODUCTION

This report describes changes in the design of the ambient air-cooled van container to improve its performance when carrying agricultural products requiring moderately low transit temperatures from various parts of the United States to Europe. It discusses test shipment procedures and illustrates ambient air temperatures encountered during transit. Commodity pulp temperatures, commodity condition upon arrival, and the forced-air system used for cooling purposes are also discussed.

The original air distribution system was described in Marketing Research Report No. 988.2/ Principal changes made in the forced air distribution system were to relocate the blower, the intake openings, the exhaust outlet and louvers, and all controls to the front of the van container. This was done primarily to eliminate the problems and hazards involved in routing electrical wiring to both the front and rear of the van container as required in the proposed design described in Marketing Research Report No. 988. The latest design modification not only eliminated a safety hazard from electrical wires but also increased the compactness and flexibility of the system. A two-stage thermostat controlled the electric heater and louvers to divert part or all of the exhaust stream of air for recirculation and heating for cold weather operation.

The effectiveness of the modified air distribution system was evaluated by conducting two test shipments of agricultural commodities. The first test shipment consisted of grapefruit from Florida to France and the second, of garlic from New York to France. Both commodities arrived overseas in satisfactory condition and were sold through normal marketing channels.

BACKGROUND

At certain times of the year when climatic conditions in the North Atlantic and North Pacific sealanes are favorable, convertible, dry freight van containers can be used to carry agricultural perishables requiring

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1/ Agricultural economist, Transportation and Packaging Research Laboratory, Agricultural Marketing Research Institute, Northeastern Region, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Md. 20705.

2/ Biales, Albert. Waterproof Marine Ventilation System for Dry Freight Van Containers. U.S. Dept. Agr. Market. Res. Rpt. No. 988, 23 pp. 1973.

moderately low transit temperatures from producing regions in the United States to overseas markets. Results of tests with commercial shipments of watermelons and grapefruit, reported in Marketing Research Report No. 988, show that ambient air can be used as a cooling medium during ocean transit.

In addition, a fleet of convertible, dry freight van containers would provide an alternative to the expensive refrigerated van containers for use during peak production periods but with limited utilization during part of the year due to lack of cargo requiring refrigeration.

Use of this modified system would have the following advantages for the carriers, the agents, and associated companies, such as container lessors, shippers, and receivers for the products:

(1) Savings in transport costs by facilitating the use of less expensive, more plentiful, dry freight van containers

(2) Increase of about 10 percent more cargo in a standard 40-foot-long dry freight van container because of reduced tare weight of the container and increased interior cube as compared with conventional refrigerated van containers

(3) Reduction in service cost for the equipment as compared with that required by refrigerated van containers

(4) Reduction in capital requirements for the equipment assigned to carry these products as compared with refrigerated van containers

(5) Significant energy savings by reducing intransit energy use per unit and by considerably reducing maintenance requirements.

COST COMPARISON OF VAN CONTAINERS

Shipment of a commodity in a van container equipped with the ambient air-cooling system has potential cost saving benefits. The average initial investment cost of a fully insulated refrigerated van container is approximately $20,000 and that for a dry van container approximately $5,000. The initial high investment cost and the high maintenance costs of the refrigerated van container, which requires a fully equipped maintenance facility, tend to keep the supply of these expensive units to a minimum.

The cost of modifying a dry freight van container for ambient air-cooling would be about $1,500 to $2,000. Indications are that carriers could negotiate a freight rate reduction for transporting ambient air-cooled van containers. If this rate reduction were 20 percent of the refrigerated rate, this could mean a savings of $600 per shipment compared to a load of produce shipped in a refrigerated van container with a freight charge of $3,000. Additional savings could also be possible on a return load, such as flower bulbs, from Europe to the United States.

EQUIPMENT

The van container used in these tests was a conventional 40-foot aluminum dry freight van container with a solid wood floor and 1/4-inch plywood lining on the interior surface of the sidewalls. There was no interior surface lining on the roof, front end wall, or rear doors. Two intake openings and one exhaust opening were cut in the front end wall of the container (fig. 1). All openings were covered with an aluminum mesh screen conforming to TIR requirements.3/ The intake openings were fitted with specially constructed air-water separation baffles to let in fresh air and keep out sea spray and rainwater during ocean transit.

A false bulkhead or cargo retaining wall was installed at the front end of the van 12 inches from the inside surface of the end wall. The wall was made of 3/4-inch-thick plywood panels bolted to 2- by 2-inch "L"-shaped crossmembers

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3/ TIR is the abbreviation for "Transports Internationale Routier," or International Road Transport. It refers to the so-called TIR Convention, which fixes the conditions for the free movement of van containers between signatory countries. The Convention has been ratified by most of the trading nations of the world, including the United States. Under the terms of the Convention, all signatory countries allow loaded and empty van containers meeting the TIR specifications and accompanied by an appropriate TIR carnet (a shipping document guaranteeing the payment of all customs duties) to move freely through the ports of entry to interior destinations and to pass through one country to a destination in another country without the usual border delay for customs inspections. TIR grids or screens are required on van container ventilation openings to prevent rats and other rodents entering the container and being carried from one country to another. They also prevent theft and smuggling.

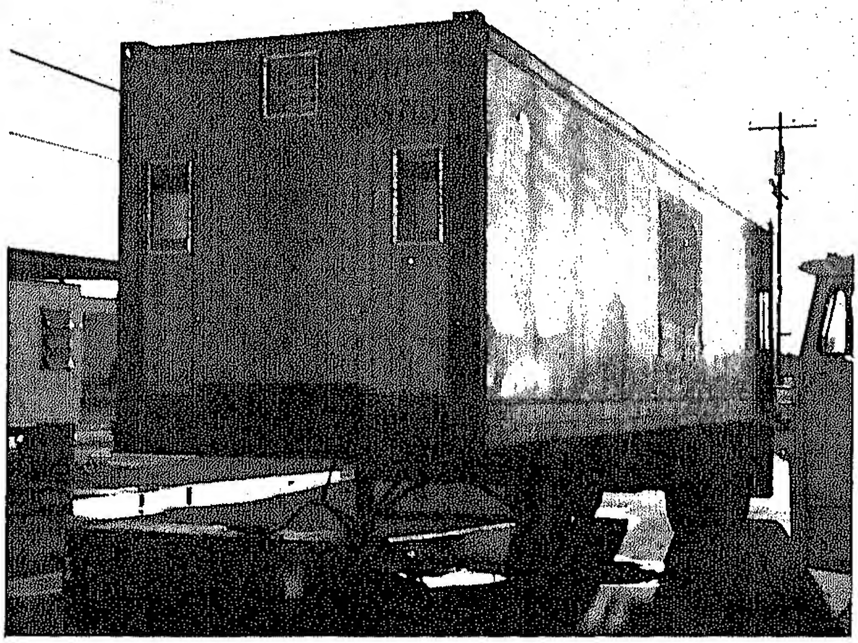

Figure 1.--Modified dry freight van container used for ambient air-cooling of produce with one (top) blower exhaust opening and two (lower) fresh air intake openings.

welded to the sidewalls. The space between the bulkhead and the front end wall was used to house the air plenums, duct work, and controls. A 10-inch opening was left between the bottom of the bulkhead and the floor to serve as the air inlet to the cargo compartment.

A 1,000 cubic feet per minute centrifugal blower was mounted near the top of the false bulkhead. The blower intake was located inside the cargo compartment and a duct from the blower outlet carried the discharge air across the space between the bulkhead and the front end wall allowing the air to be discharged directly to the outside. Figure 2 (top) shows interior front wall with two fresh air intakes, the exhaust duct, and the support framing for the false bulkhead. Figure 2 (bottom) shows the false bulkhead and installed blower. The fan exhaust duct had two openings as shown in figure 3. One opening led to the outside of the van container. The other opening faced downward toward the heating element. A thermostatically controlled louver was installed in each exhaust duct opening to divert the air to the outside for ventilation or downward for heating and recirculation.

Figure 3 illustrates the front section of a loaded van container with the forced air circulation system installed. The system functioned in one of two operational modes:

(1) Ventilating--using ambient air for cooling

(2) Recirculating--during cold weather when heating was necessary to prevent product damage by chilling or freezing.

The blower operates continuously in either mode. A two-stage thermostat controls the electric heater and blower operation. In the ventilating mode, when the intake and exhaust louvers opened, the recirculation louver closed. Cool ambient air, which was pulled into the van container through the intake opening, circulated through air channels in the load and through the boxes where it picked up product heat. The warmed air was then exhausted from the van container through the exhaust opening.

In the recirculating cycle, when the intake and exhaust louvers close, the recirculation louver opens. In this mode the heater is automatically turned on by the thermostat when the temperature of the incoming air falls below the thermostat setting. The incoming air is driven downward through the heater into the cargo space and is returned to the blower for recirculation.

SHIPPING TEST RESULTS

Two shipments were made to test the performance of the forced air system.

Grapefruit

The first test shipment consisted of grapefruit from Florida placed in two van containers, one refrigerated and one ambient air-cooled. Both van containers were loaded with 950 four-fifths-bushel, corrugated fiberboard boxes

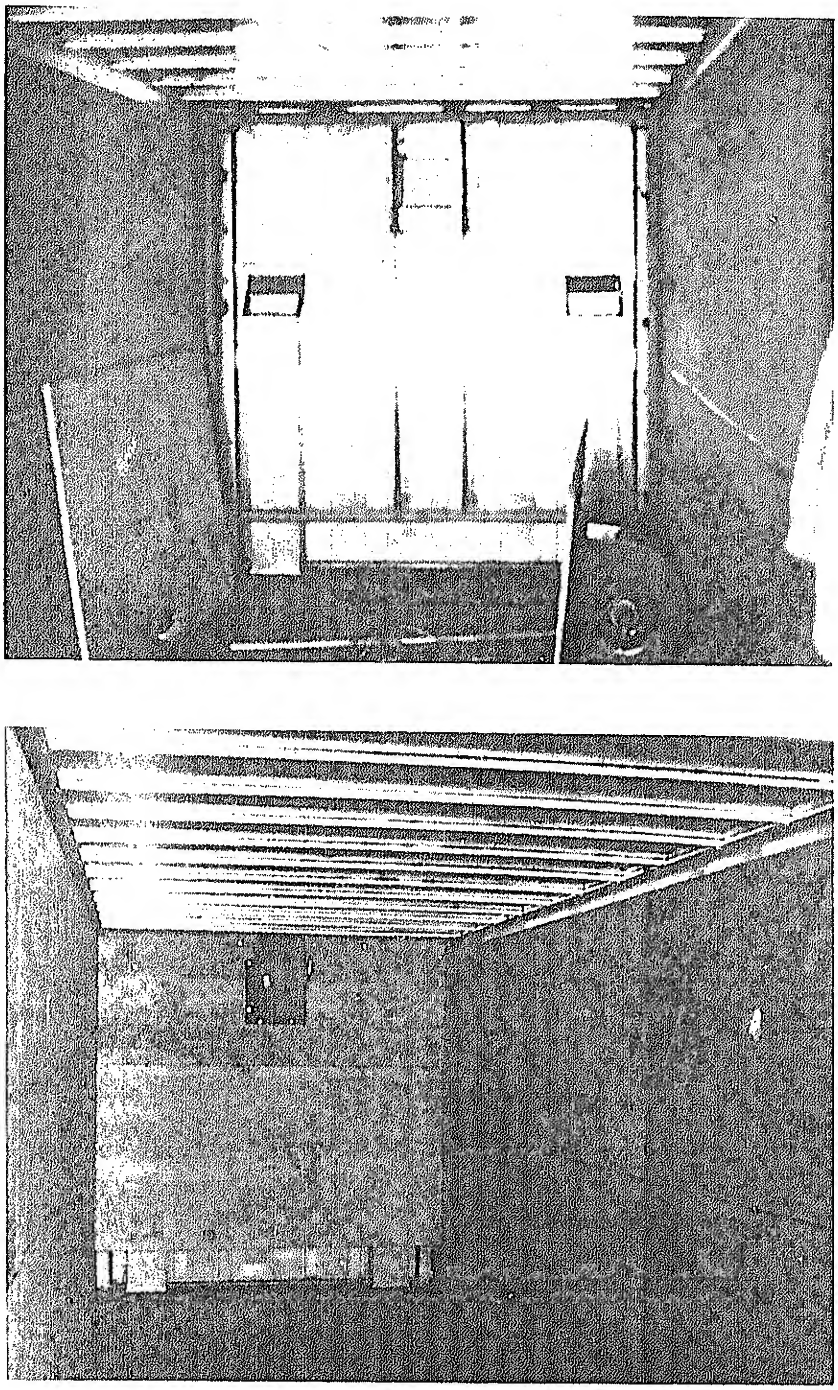

Figure 2.--Inside of container showing: Top, interior front wall with two fresh air intakes, exhaust duct, and 2- by 2-inch angle iron framework; bottom, front of container with false bulkhead and installed exhaust blower.

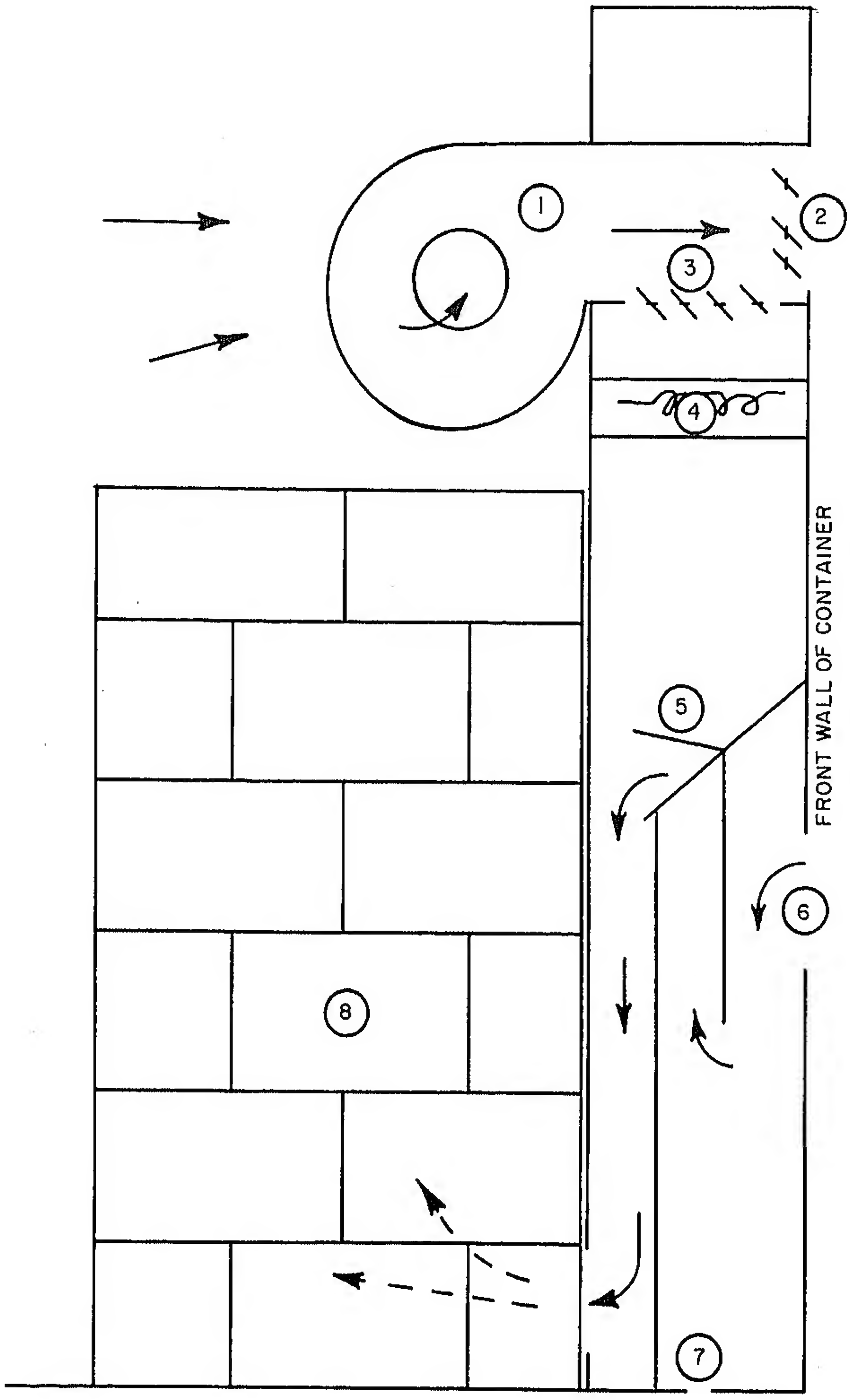

Figure 3.--Schematic depicting major components of ambient air-cooling system: 1--Blower, 2--exhaust louver, 3--recirculation louver (this louver would be closed during cooling, or ventilating, mode), 4--heater, 5--hinged intake cover, 6--fresh air intake, 7--drain, 8--agricultural products. Arrows indicate direction of airflow when system is in cooling mode.

of fresh grapefruit from the same packinghouse. Each box had two 2- by 1/2-inch ventilation slots on each side panel. There were no ventilation slots on the end panels of the boxes.

The boxes in each van container were "chimney stacked" on 40- by 48-inch corrugated fiberboard slipsheets, leaving a vertical air circulation flue from top to bottom in the center of each handling unit. Eighteen slipsheet handling units were loaded inside each van container. The slipsheet units in the refrigerated van container were stacked tightly together--the conventional way.

The slipsheet units in the ambient air-cooled van container were arranged to provide air channels extending from front to rear to provide air circulation. The first four slipsheet units were placed tightly against the bulkhead and sidewalls to prevent short-circuiting of air from the air inlet to the blower intake. This left a space of about 10 inches between the units at the center of the van container. The remainder of the slipsheet handling units (except the last two at the rear of the van container) were loaded so that a small space of about 2 inches remained between each slipsheet unit and the sidewalls of the van container and about 6 inches between each slipsheet unit at the middle of the load (figs. 4 and 5). The last two slipsheet units were placed tightly against each other at the middle of the van, thus closing off the rear of the air channel at the rear of the load.

The top surface of the load in the air-cooled van container was covered by a sheet of plastic to prevent circulating air short-circuiting the bulk of the load mass. The ambient air was drawn into the van container through the fresh-air intake and flowed downward through the air plenum between the bulkhead and the front end wall of the container. At this point, the ambient air

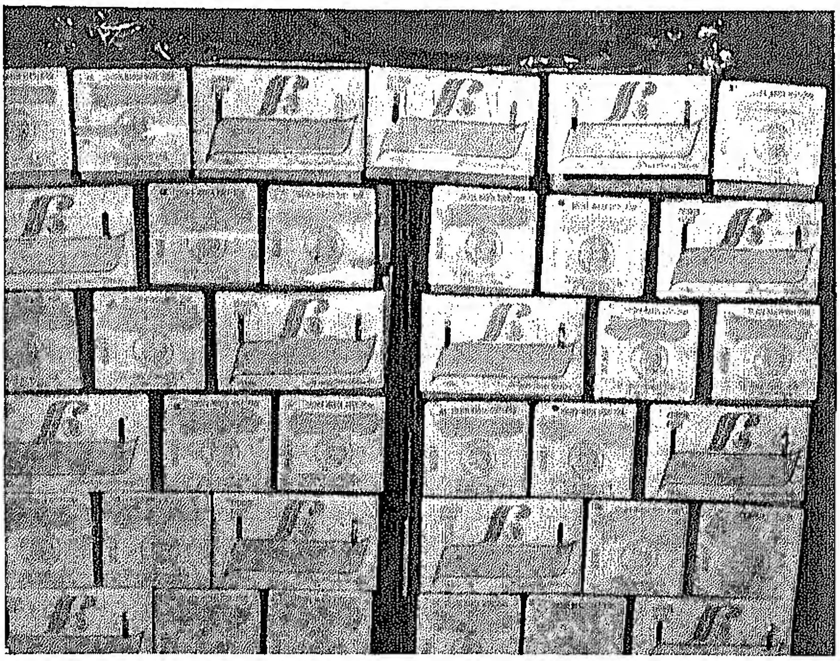

Figure 4.--Cross section view of load in ambient air-cooled van conta showing air channel through middle of load and space along sidewall air distribution in grapefruit test shipment.

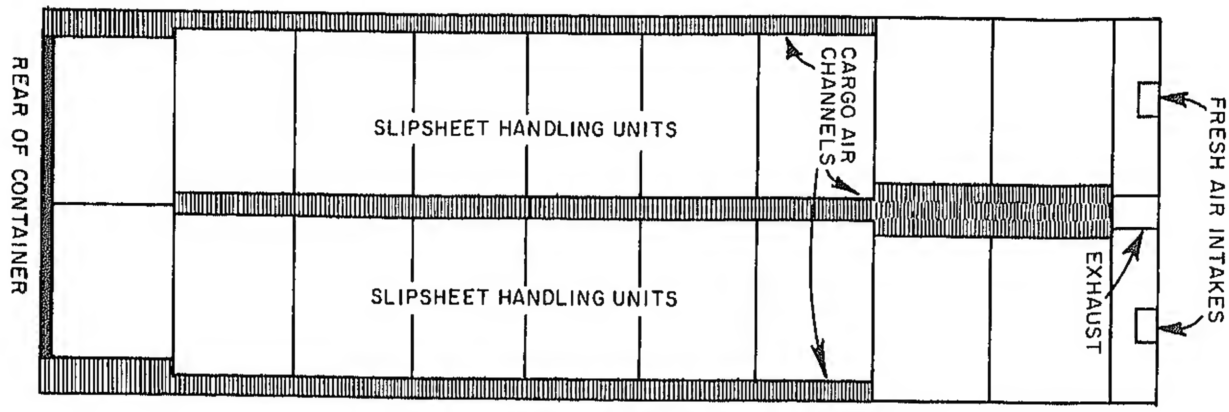

Figure 5.--Cutaway top view showing air channels used in loading pattern of slipsheet handling units in grapefruit test shipments. Top of center air channel was covered with plastic film.

entered the air channel between the slipsheet handling units at the front of the load through the air inlet at the bottom of the bulkhead. The channel through the middle of the load served as an air distribution plenum. The air in the middle channel was then drawn outward and upward through the load mass toward the sidewalls and top of the load, through the ventilation slots in the boxes and through air spaces between individual boxes, and into the lower pressure area around the periphery of the load. The blower then exhausted the air to the outside.

Airflow measurements indicated fairly even air movement throughout the entire length of the van container's interior. Temperatures of the air and the fruit were monitored in transit by remote sensing devices and recorded on magnetic tape. Figure 6 illustrates the relationship between the outside air temperatures and the grapefruit pulp temperatures inside the ambient air-cooled van container and the refrigerated van container during the transit period from Florida to France. A quality evaluation was performed at destination, comparing the grapefruit transported in the ambient air-cooled van container with the fruit transported in the control refrigerated van container (table 1).

This grapefruit test was conducted in late November. Air temperatures on the Atlantic from November through April are sufficiently low to cool grapefruit in containerized shipments using ambient air-cooling. Transporting grapefruit by using ambient air-cooling before November or after April is not recommended.

The ocean freight rate charged by the carrier for the ambient air-cooled van container was approximately 30 percent lower than that charged for a refrigerated van container of grapefruit carried on the same containership.

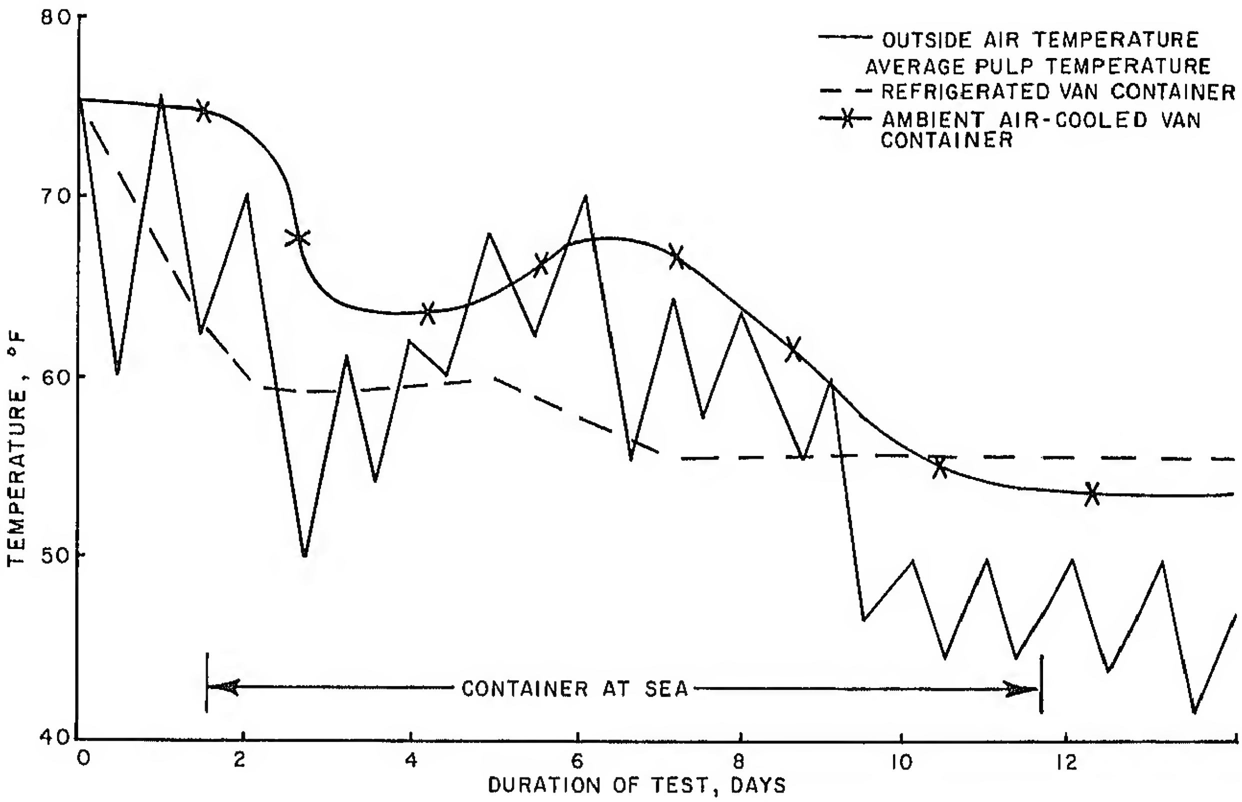

Figure 6.--Ambient air temperature and grapefruit pulp temperature during transit test of ambient air-cooled van container from Florida to France in late November.

Garlic

The second test consisted of 1,200 30-pound corrugated fiberboard boxes of garlic bulbs. The garlic was grown in Mexico, shipped by truck to New York, and held in a warehouse until shipment. The boxes of garlic were loaded in the ambient air-cooled van container for shipment to France aboard a containership.

The boxes were handstacked seven high in the van container in a 6 by 6 offset loading pattern, with lengthwise air circulation channels between the boxes from front to rear of the van container. The boxes had two ventilation slots in each side panel and three ventilation slots in each end panel. The two top layers were tightly stacked to prevent short-circuiting of the incoming ambient air to the exhaust blower (fig. 7).

Recording instruments were placed inside the container to measure temperatures and relative humidity during transit. The average pulp temperature of the garlic and the relative humidity inside the van container are presented in figures 8 and 9. There was no damage or deterioration of the product at overseas destination, and the consignees were satisfied with quality and condition of the garlic.

Table 1.--*Condition of grapefruit at destination in experimental ambient air-cooled and control refrigerated van container shipments from Florida to France in late November* 1/

Sample location	Fruit sampled	Size of fruit	Decay	Deformation Slight	Deformation Serious	Total
	Number		*Percent*	*Percent*	*Percent*	*Percent*
	CONTROL REFRIGERATED VAN CONTAINER					
A	144	36	0.02	0.28	0.19	0.49
B	160	40	.02	.15	.14	.31
C	160	40	.01	.16	.11	.28
D	192	48	.01	.16	.05	.22
E	192	48	.02	.15	.08	.25
Total	848	--	.08	.90	.57	1.55
	EXPERIMENTAL AMBIENT AIR-COOLED VAN CONTAINER					
A	144	36	0.04	0.26	0.27	0.57
B	144	36	.05	.09	.16	.30
C	144	36	.04	.13	.22	.39
D	192	48	.04	.07	.14	.25
E	192	48	.02	.12	.17	.31
Total	816	--	.19	.67	.96	1.82

1/ Four sample boxes for inspection were drawn from each location, in each load, as follows: One from top layer, one from middle layer, and two from the bottom layer. Location "A" was at rear of van container, location "E" at front of van container, and locations "B," "C," and "D" were at equally spaced positions from rear to front, respectively.

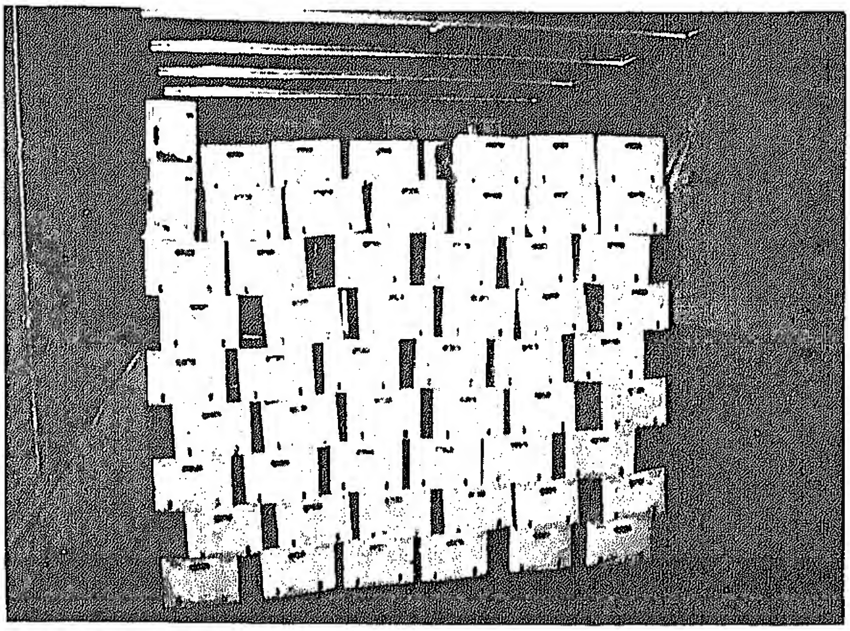

Figure 7.--Cross section of a handstacked load of garlic in corrugated fiberboard boxes. Spaces between boxes provide air circulation channels from front to rear of van container.

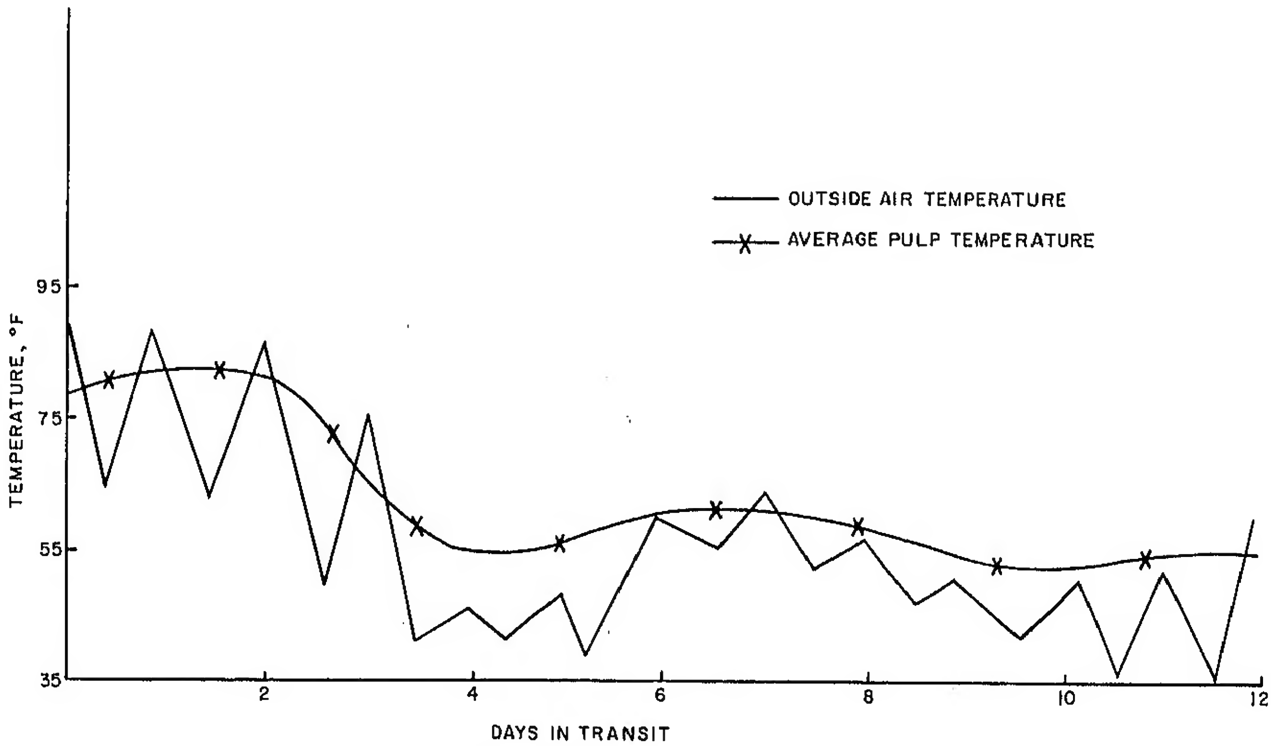

Figure 8.--Outside air temperature and garlic pulp temperature during transit test from New York to France in April.

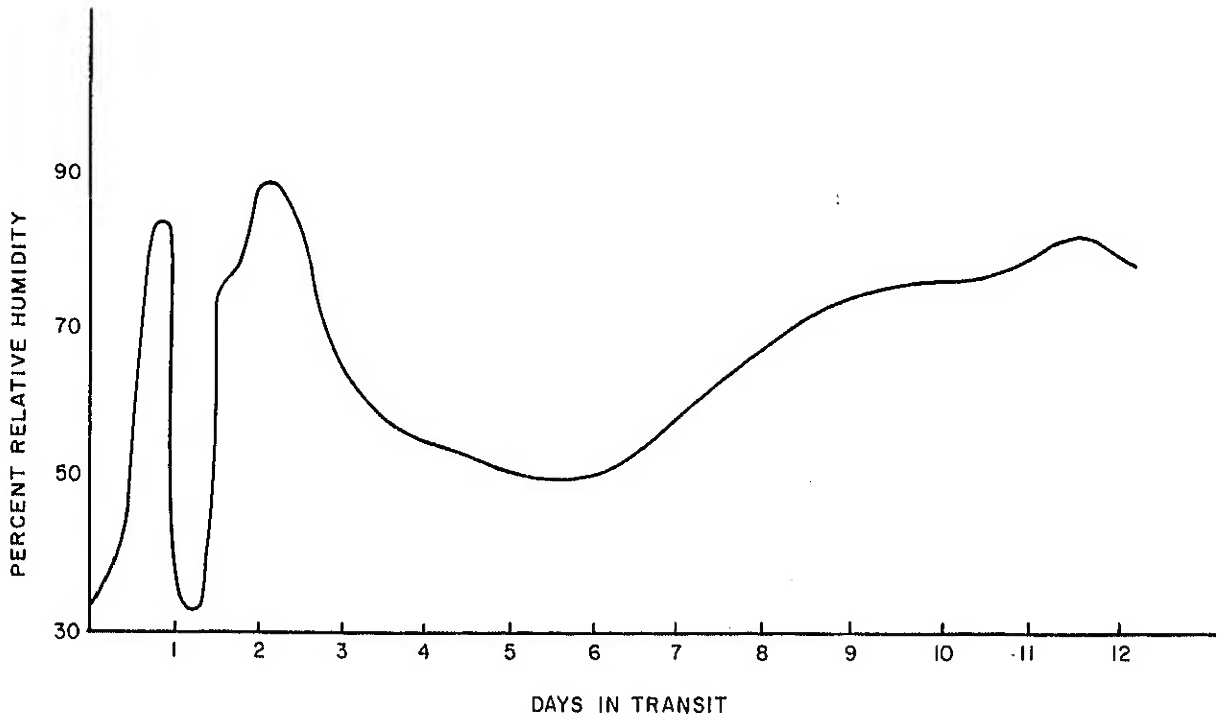

Figure 9.--Relative humidity in ambient air-cooled van container during transit test from New York to France in April.

TEMPERATURES

Pulp temperatures of both grapefruit and garlic averaged between 75° and 80° F when loaded into the ambient air-cooled van container. Neither commodity was precooled before loading. Both were held for 1-1/2 days at the marshalling yard before loading on containership. Ambient air temperatures at the marshalling yard where the grapefruit was held ranged from a low of 60° at night to a high of 78° during the day. At the yard where the garlic was held the ambient air temperatures ranged from 63° at night to 85° during the day. The average pulp temperature of the grapefruit rose only slightly and that of the garlic rose 7° during this holding period.

Air temperatures inside the van container were highest just below the ceiling during the warmest part of the day when the van container was exposed to direct sunlight. This caused slight heating of the commodity in the top layer of the load. These high temperatures, caused by heating of the roof from solar radiation, occurred while the container was parked in the marshalling yard before loading aboard ship at the port of origin. Van containers using ambient air-cooling should be scheduled for loading so that a minimum of time elapses between loading the commodity into the van container and ship's departure, especially if the commodity is being shipped from an area with a warm climate.

Commodity pulp temperatures fell rapidly once the containers were loaded aboard ship and the ocean voyage began. They remained fairly uniform throughout the van container during the 12-day voyage. This indicated that the ambient air-cooling system was performing satisfactorily.

At night when the ambient air temperatures dropped abruptly, the temperature of the aluminum roof skin fell below the dewpoint of the air inside the van container. Then condensation formed on the interior roof surface of the van container. The condensation, however, was not excessive and did not cause any damage to either the garlic or the boxes.